Exhibit D

Construction of an AOP System at SCWA

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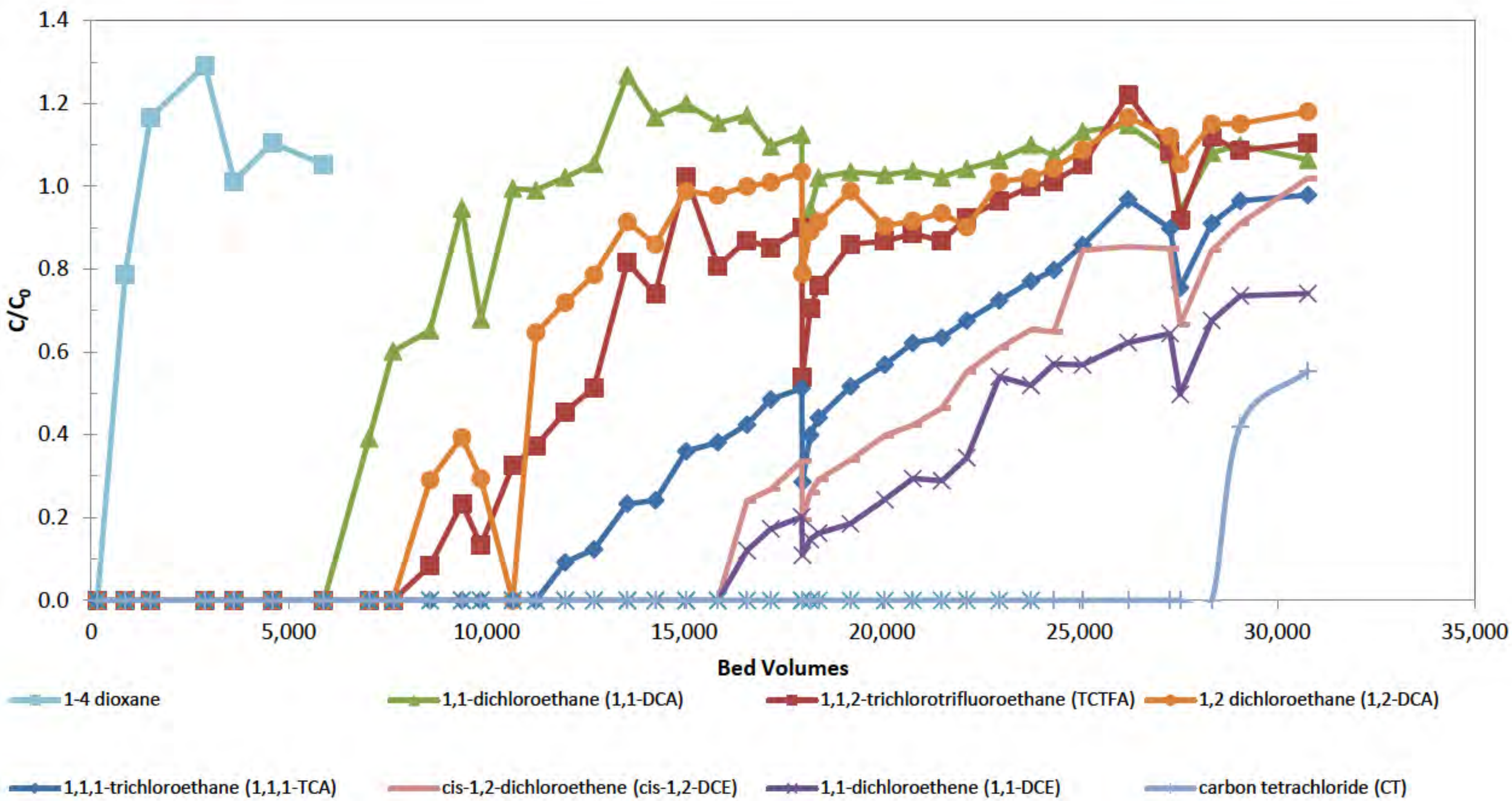
Outline

- Why AOP?
- AOP Fundamentals
- SCWA 2011 AOP Pilot Study
- Permitting / Construction a Full-Scale AOP System

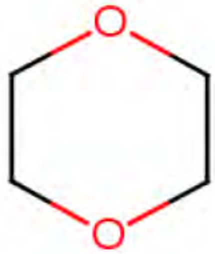
Why AOP?
Contaminant Breakthrough in GAC



Why AOP?

Treatability Table – Selected GW Contaminants

Contaminant	Freundlich K	Henry's H*	Log K_{OW}
aldicarb	8.27	--	1.13
tetrachloroethylene	7.5	0.361	3.4
trichloroethylene	2.6	0.23	2.42
1,2,3-trichloropropane	2.5	0.005	2.27
carbon tetrachloride	0.57	0.56	2.83
1,2-dichloropropane	0.4	0.0538	1.98
Cis-1,2-DCE	0.212		1.86
1,2-dichloroethane	0.129	0.0257	1.48
1,1-dichloroethane	0.0646	0.115	1.79
1,1,1-trichlorethane			2.49
1,4-dioxane		0.0002	0.27
dichloromethane	0.0034	0.0616	



1,4-Dioxane

Advanced Oxidation Process (AOP)

- UV light systems: commonly used for DW disinfection
- UV AOP:

  $\boxed{\text{UV + oxidant} \rightarrow \bullet\text{OH}}$

  highly reactive •OH radical formed.
- Common oxidants: H_2O_2; O_3; Cl_2
- Effective for oxidation of many organic contaminants
- Most common AOP uses:
  - indirect potable reuse
  - GW remediation
- Process transforms, does not remove.

Oxidant Potentials – Common Oxidants

Oxidant	Oxidation Potential (eV)
•OH	2.80
O_3	2.07
H_2O_2	1.77
Hydroperoxyl Radicals	1.70
Permanganate	1.67
Chlorine Dioxide	1.50
Chlorine	1.36
O_2	1.23

Unique AOP Terms

- Transmissivity
  - Ability of light to penetrate through water
- Scavenging
  - •OH reacts with many background contaminants
    - NOM, DOC, alkalinity, chloride, sulfate and nitrate.
  - Inhibits destruction of target contaminants
- Quenching
  - Conversion from oxidant → •OH << 100%
  - Residual oxidant (H_2O_2; Cl_2; O_3) persists in AOP Effluent
    - Can get >75% carry-over of H_2O_2
  - Full-scale AOP - Quench excess H_2O_2 with Cl_2 or GAC

Types of AOP Systems

- Different reacting systems; all generate •OH
  - H_2O_2 / UV
  - O_3 / UV
  - O_3 / H_2O_2
  - TiO_2 / hv / O_2 (photocatalytic)
  - H_2O_2 / Fe (Fenton)

SCWA – 2011 AOP Pilot Study

- Objective - Evaluate effectiveness of UV AOP for destruction of GW contaminants
- Study conducted @ SCWA pump station
  - Contaminants: 1,4-dioxane; 1,1-DCA, 1,1-DCE, TCE
  - Existing GAC Adsorbers:
    - Calgon Model 10 – 40K lb. 8x30 bituminous GAC

2011 AOP Pilot Study

- Acknowledgements
  - Scott Meyerdierks - SCWA
  - Ben Stanford; Erik Rosenfeldt – Hazen & Sawyer
  - Alan Royce – Trojan UV

SCWA - COMMERCIAL BLVD. AOP STUDY

2011 AOP Pilot Study - SCWA

- Trials:
  - Varied:
    - Flow rate: 20 – 200 GPM
    - UV Intensity: 0% (lamps off); 60% - 100% (lamps on)
    - Oxidant type: H_2O_2 and NaOCl
  - H_2O_2 Dose: 2 – 6 mg/L
- Determined:
  - Contaminant removal
  - By-product formation

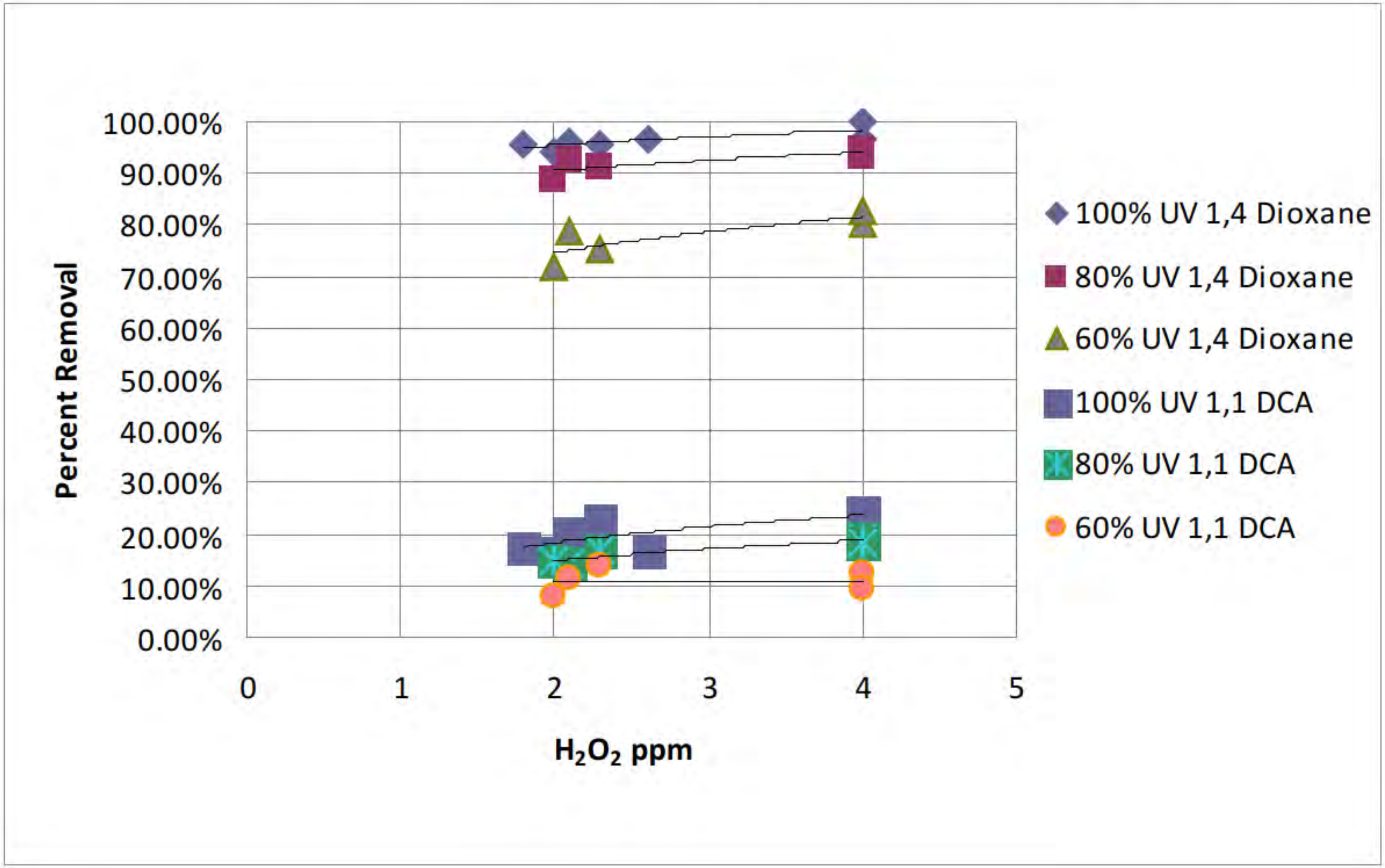
AOP Pilot Description

- Trojan UVPhox™ 8AL30
- 8 low-pressure high-output amalgam lamps; 2 kW
- 135 L reactor volume
- Mixing loop
- Calgon FloSorb® GAC w/ 165# F300 virgin bit. GAC

AOP Pilot Description

- Control Panel
- Adjustable UVI
- UV Transmissivity Monitor
- 35% H_2O_2
- FlexFlo variable peristaltic pump

% Removal vs. Peroxide Dose - 150 gpm



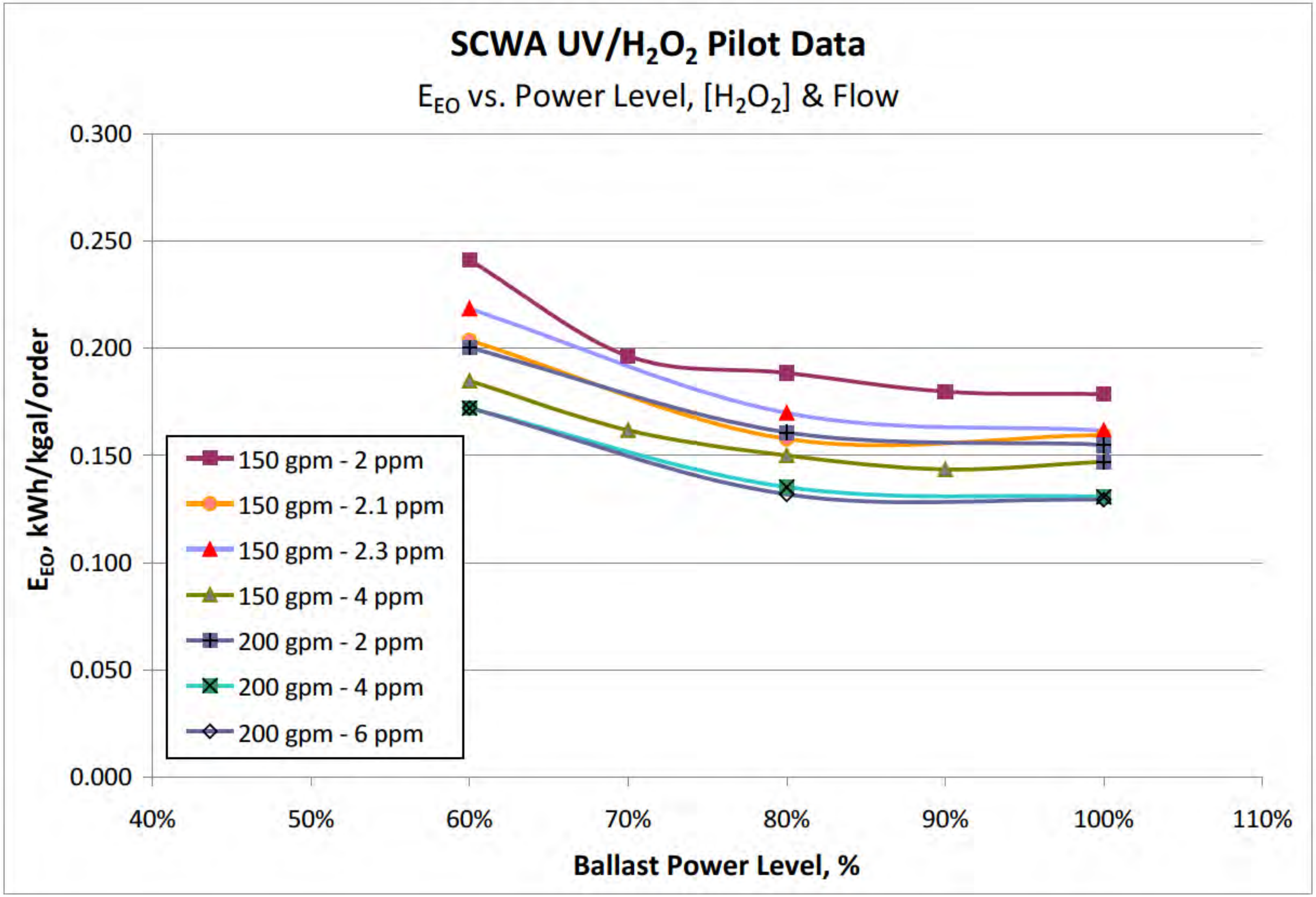
Concept of EEO

- EEO = Electric Energy per Order
  - Energy required for 1-log destruction
  - Units = kWh/m^3/order

$$EE/O = \frac{\text{UV Reactor Power Draw (kW)}}{0.06 \times \text{flow rate (gpm)} \times \log\text{(Influent conc. (ppt) / Effluent conc. (ppt))}}$$

  - f(reactor efficiency)
    - WQ; reactor characteristics; contaminant; oxidant type/concentration

EEO for 1,4-Dioxane



Predicted Operating Cost
(from 2011 pilot study)

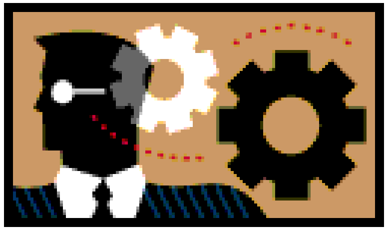
- Peroxide - $0.17/KGal
- Electrical - $0.04/Kgal
- System Consumables - ?

AOP Full-Scale System

- Objectives - SCWA:
  - Performance
  - Design / Operational Concerns
    - Process reliability
    - Ability to fit in existing treatment scheme
    - System I&C / SCADA Integration
    - Effect on downstream GAC
    - H_2O_2 storage / handling issues & requirements
    - Regulatory requirements
  - Cost

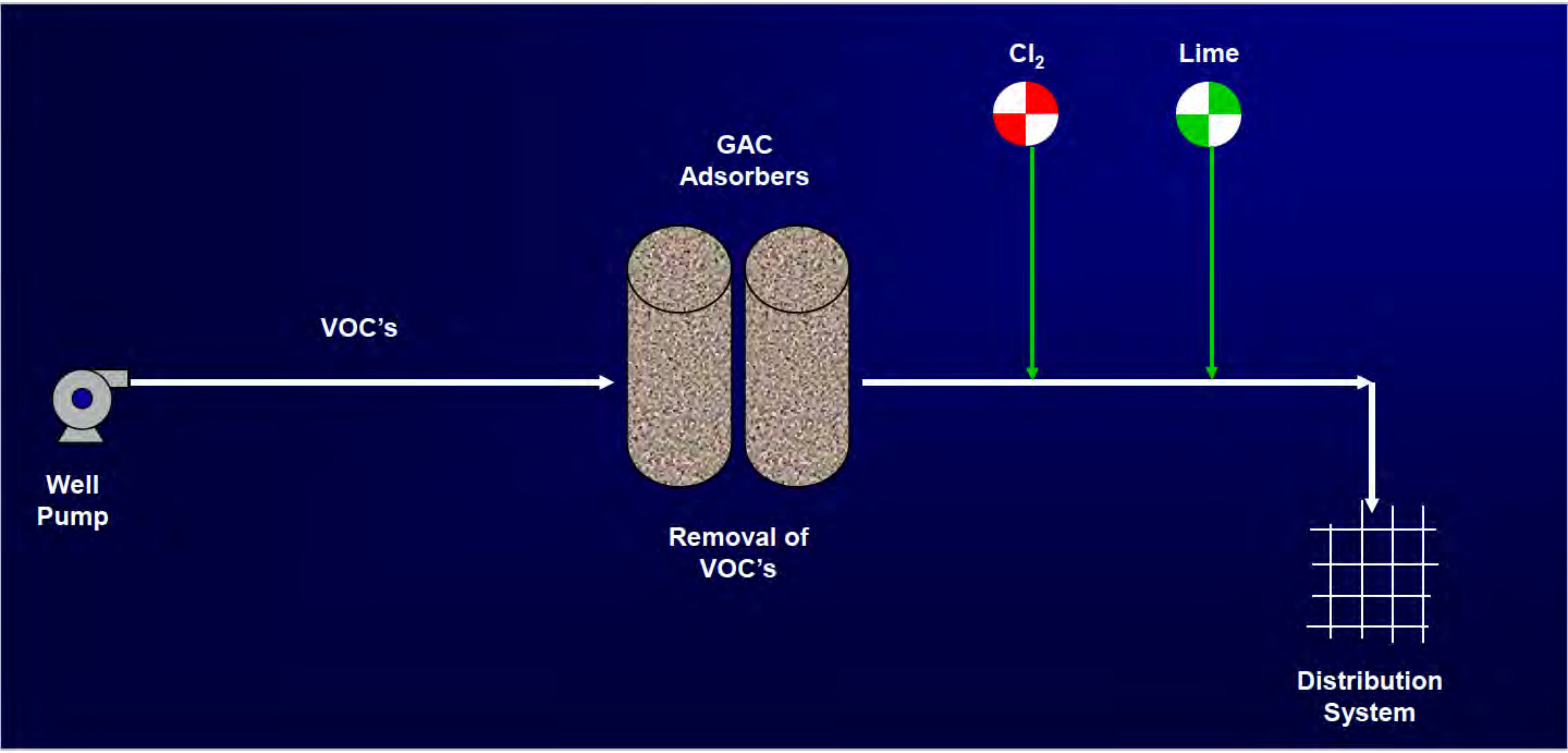
AOP Full-Scale System

Design Review Phase

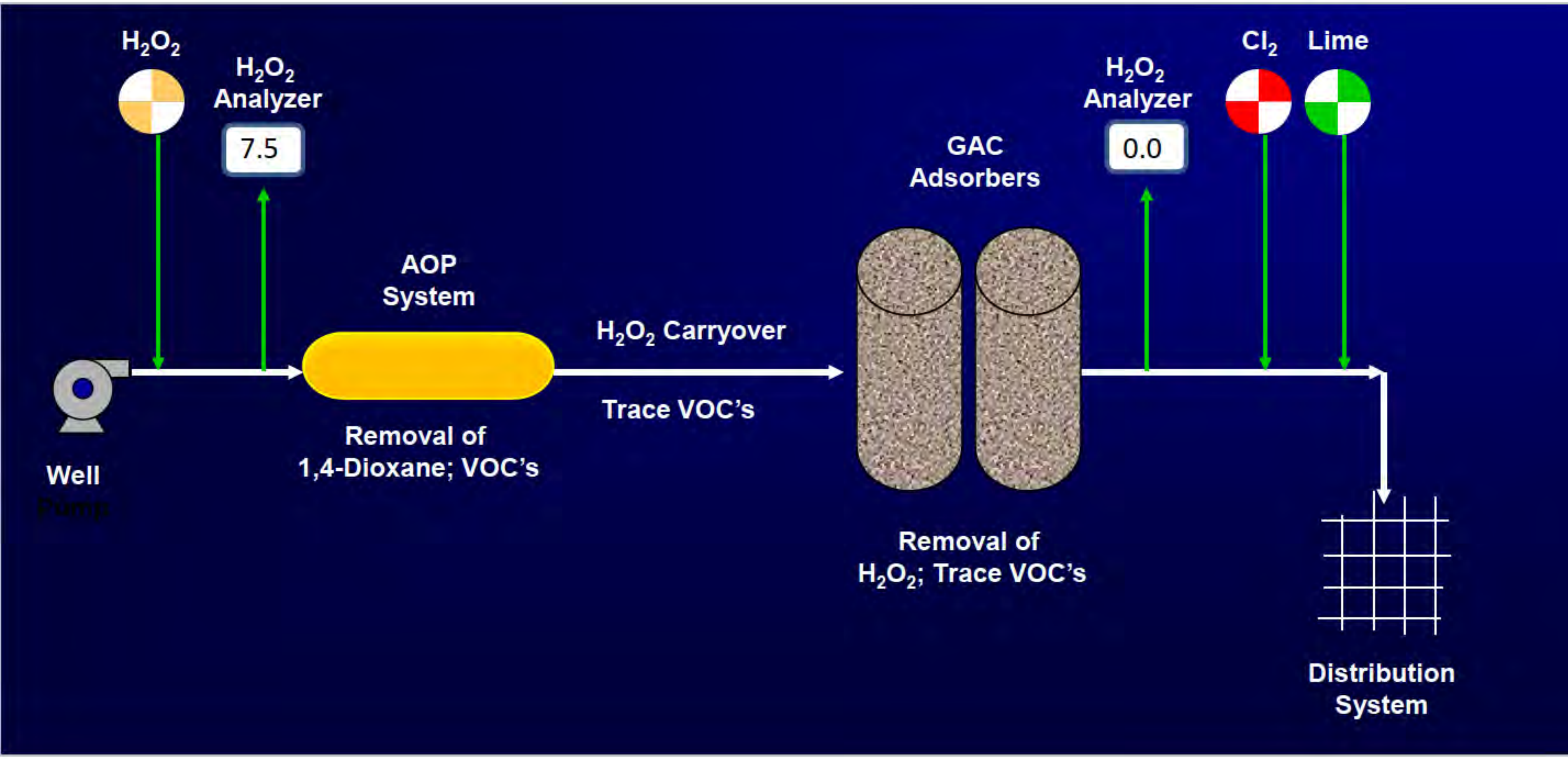


- SCDHS / NYSDOH Concerns
  - General Design Comments
  - System Reliability
    - On-line analyzers
    - Alarms / interlocks
    - Ability to BTW
  - Effects on GAC
  - By-Product Formation

Current Process Flow Diagram



Proposed Process Flow Diagram



AOP System Location

AOP - Accessibility

AOP – BTW Capacity

GAC Modifications

GAC Modifications

Construction of AOP System

Construction of AOP System

AOP Construction

AOP Construction

AOP Construction

2011 Pilot Study

AOP Construction

AOP Reactor End Cap

Specific Regulatory Concerns

- WQ Sampling

Parameter	AOP Inf	AOP Eff	GAC Eff
1,4 - Dioxane	X	X	X
H_2O_2		X	X
Aldehydes	X	X	X
AOC	X	X	X
Carboxylic Acid	X	X	X
VOCs	X	X	X
Tot. Coliform	X	X	X

AOP – Analytical Methods

- Peroxide Field Methods
  - Not EPA Approved
  - On-Line Analyzers
  - Test Kits - Field Verification
- UV Transmissivity

Peroxide Field Test Methods

Method	Trojan ECT06	Palintest	HACH HYP-1
Type	Colorimetric w/ meter	Colorimetric w/ meter	Colorimetric / end point titration
Reagent Chemistry	DPD / Peroxidase	DPD / Potassium iodide	Ammonium molybdate / sulfite
Dilution required?	Yes – to < 1.0 ppm	Yes – to < 2.0 ppm	Yes – to < 2.0 ppm
Ease of use	Moderate	Easy / Moderate	Easy / Moderate
Comments	Most involved method. Requires preparation of peroxidase solution	1 reagent tablet	3 reagents. Visual titration Blue $\longrightarrow$ Colorless

Peroxide

- 50% Peroxide
- Oxidant Concerns
  - Design
  - Handling
  - Regulatory
  - Operational

Start-Up / BTW Matrix

	Peroxide Dose			
UV Intensity	0 mg/l	4 mg/l	7 mg/l	10 mg/l
Lamp Power 100%		6	3	9
Lamp Power 80%		7	4	10
Lamp Power 60%		8	5	11
Lamp Power 0%	1		2	

= By-product sampling included

AOP Start-Up

- SCWA – Conduct initial 30 day BTW period
- Confirm system operation
- Determine:
  - Log removal
  - By-Product formation
- Review data w/ regulators
  - Completed Works Approval

Questions?